• Elekta XVI CBCT: 120 kV, 649 mAs, 649 frames, M20F0, 360° scan
• Elekta XVI fluoroscopy: 120 kV, AP, 1 mAs per frame, 5.5 Hz frame rate, exposure time of 3min, S20F0

IBC:

Kawasaki robotic arm with Varian A-277 X-ray tube, B-130H housing and Varian PaxScan 4030D flat panel detector:
• planar kV: AP: 125 kV, 100 mA, 12 ms; LR: 125 kV, 160 mA, 25 ms
• CBCT: 120 kV, 3 mA, 10 Hz frame rate, 430 frames, scan from -100° to +100°

The energy dependent sensitivity of the TLDs was taken into account by corrections based on the respective energy spectrum of the beams. Read-out (Harshaw TLD 5500 reader), calibration and annealing of the TLDs was performed at the CRD.

Results: The imaging techniques were grouped in low- and high-dose according to the absorbed dose per exam. All results are shown in Fig. 1. The CBCT at the IBC is included in both graphs to facilitate direct comparison. Generally the OAR doses depended on the imaging modality and the position of the OARs. The doses for volumetric imaging were on average 2.5-130 times higher than for the planar or stereoscopic image pairs. The dose caused by a CBCT scan at the CRD was ~20 times higher than at the IBC as more projections with higher mAs setting were used. The skin dose was higher where the skin was closer to the X-ray tube (CBCT) or at the entrance side of the beam (anterior, sinister for planar kV; posterior for ExacTrac). The highest dose per exam (up to 150 mGy to the skin) originated from the 3 min fluoroscopy.

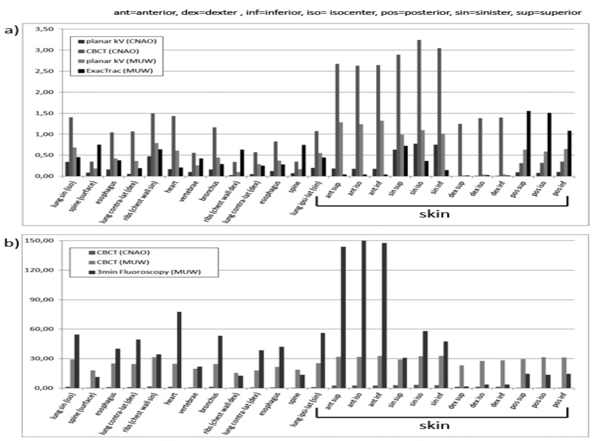

Figure 1. Absorbed dose per exam (in mGy) for a) low- and b) high-dose modalities.

Conclusions: Imaging modalities like planar kV or stereoscopic imaging result in very low doses (<1.6 mGy) to the patient. To assure accurate positioning imaging should be performed on a daily basis. However, when aiming to image a moving target during irradiation, one has to optimize protocols and imaging time, as the induced dose to OARs cannot be neglected.

PROFFERED PAPERS: PHYSICS 2: SMALL FIELD CHALLENGES

OC-0063

Commissioning CBCT based Monte Carlo treatment planning system for small animal stereotactic irradiation

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Purpose/Objective: Commissioning a cone beam CT (CBCT)-based Monte Carlo treatment planning system for a commercial small animal stereotactic irradiator.

Materials and Methods: The BEAM/EGS Monte Carlo code was used to model 225 kV photon beams from a commercial small animal stereotactic irradiator (X-RAD 225Cx, Precision X-Ray, North Branford, CT). The unit was calibrated in accordance with the recommendations of AAPM TG-61. Both in-air and in-water calibrations were performed at a 30.5 cm source-to-surface distance (SSD) using a 40x40 mm^2 square reference applicator. The output factors for various applicators were measured using various dosimeters (ionization chamber, radiochromic film) and compared with MC simulations. The gamma index method and AAPM TG 53 recommendations were used to benchmark planar radiochromic film measurements against Monte Carlo simulations in both homogenous and heterogeneous mediums. Benchmarks were performed in both homogeneous and heterogeneous media. CBCT calibration curve was created to convert to a CBCT data to density matrix. The CBCT images obtained on the XRAD 225Cx irradiator were converted to a material /density matrix using CBCT calibration curve.The material /density matrix is used as an input to DOSXYZnrc for MC dose computation. The measured and MC computed absolute doses compared for single and multiple beams in both homogenous and heterogenous mediums for 10 mm field size. The isodose distributions were compared using the gamma index method both for single and multiple beams.

Results: The in-water and in-air absolute dose measurements demonstrated excellent agreement of 3.42 and 3.45 Gy/min, respectively. MC and measurement agreement of output factors was within 3% for all field sizes. The agreement between simulated and measured absolute dose in CBCT based homogeneous medium for single and multiple beams was within 1%. In CBCT based heterogeneous conditions, it was within 1.5%. Gamma map comparisons between MC and measurement with 3% /0.5 mm criteria indicating 98% passing rate for 10 mm field size.

Conclusions: The MC dose calculation in CBCT data was validated in a homogenous medium. The comparison between MC and measured dose distributions was quantitatively validated using the gamma index method for 10 mm field size in CBCT data based homogenous medium. A relation was formed between the Monte Carlo dose distributions and irradiation absolute dose rate. Finally Monte Carlo calculated absolute dose and measured absolute dose in heterogeneous medium are in good agreement.

OC-0064

Development and validation of a treatment planning system dedicated to pre-clinical research

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Purpose/Objective: A new field of research in radiotherapy is small animal image-guided precision radiotherapy. In this, radiotherapy procedures are scaled down to the level of structures in small animals, to study treatment strategies which may be translated into human radiotherapy. To enable this, a combination of high-resolution imaging and small field precision irradiation equipment is needed. The irradiations need to be downscaled in energy, from megavolt to kilovolt energies to avoid extensive buildup regions and beam penumbras. To ensure that complex treatments can be delivered, mimicking patient treatments, a versatile treatment planning system tailored to small animal radiotherapy, is needed, which is unavailable currently.

Materials and Methods: A treatment planning system for small animal pre-clinical radiotherapy was developed, named Smart-Plan (Small Animal RadioTherapy Planning system). It is capable of planning the irradiation of small specimens such as mice or rats with either multiple coplanar beams or arcs for 225 kV x-rays. This low photon energy mandates careful assignment of the specimen tissues because of the strong dependence of the photon interaction coefficients (photo-electric effect) on the tissue composition. To this end, the micro-CT image from the onboard high-resolution imager is converted into a density and composition map, by calibration and visual inspection of the material map. Smart-Plan handles accurate beam positioning and absolute dose calculation is performed with Monte Carlo simulations based on a detailed model of the complete irradiator, including an accurate model of the focal spot distribution of the primary electron beam hitting the x-ray target. Smart-Plan comprises an interface to transfer treatment parameters to the irradiator. To speed up the calculation multiple simultaneous simulations are performed on a multi-core computer. To validate Smart-Plan planned and measured dose distributions in a multislab heterogeneous phantom were compared.

Results: